SUMMARY OF RESEARCH

Final summary of activity conducted under

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Support for ISU's
2003 Summer Session Program and the Theme Day on
"Upcoming Technologies for Space"

Period of Performance for the Grant: December 1, 2003-November 30, 2004
Period covered by this Report: December 1, 2003-November 30, 2004

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Summary of Research

The 2003 Summer Session Program of the International Space University (ISU) was conducted at the ISU Central Campus in Strasbourg, France, July 5-September 6, 2003. Attending the Summer Session were 114 students from 27 countries including the US.

The International Space University (ISU) offers its students a unique and comprehensive educational package covering all disciplines related to space programs and enterprises – space science, space engineering, systems engineering, space policy and law, business and management, and space and society. By providing international graduate students and young space professionals both an intensive interdisciplinary curriculum and also the opportunity to solve complex problems together in an intercultural environment, ISU is preparing the future leaders of the emerging global space community.

Since its founding in 1988, ISU has graduated more than 2200 students from 87 countries. Together with hundreds of ISU faculty and lecturers from around the world, ISU alumni comprise an extremely effective network of space professionals and leaders that actively facilitates individual career growth, professional activities and international space cooperation.

ISU's interdisciplinary Student Theme Days and Student Workshops are intended to have great educational value for the participants. Along with the interdisciplinary Core Lectures, they apprise the students of state-of-the-art activities, programs and policies in space-faring nations. They also provide ISU students the opportunity to meet world experts in space-related subjects.

In-space propulsion has become a major constraint on space exploration. For interplanetary missions, the capability of chemical propulsion systems limits the total mass that can be sent to the outer planets. In order to ameliorate this constraint, most such missions make use of a gravity assist maneuver, which unfortunately adds considerably to the duration of the mission. There is ample incentive to develop improved in-space propulsion techniques, for commercial as well as for scientific exploration missions.

Electric propulsion, whether powered by solar generators or by nuclear reactors, offers a valuable solution to the problems posed by chemical in-space propulsion. It may be argued that solar electric propulsion is more applicable to near-Earth missions or to missions to the nearer planets, whereas nuclear electric propulsion remains operational even in the vicinity of the far outer planets. Taking into account considerations such as cost and safety it can be concluded that both types of electric propulsion are complementary having their specific niches of application. A third technology based on non-chemical sources for high efficiency propulsion is solar thermal propulsion, which may find its own specific niche in near-Earth missions or missions to the inner planets.

The ISU Upcoming Technologies Theme Day on August 14 addressed these three types of in-space propulsion (solar electric, nuclear electric and solar thermal). During the morning session the three technologies were presented, addressing for each one:

- the principle of operation and the resulting characteristics;
- the advantages offered when compared with present-day chemical propulsion techniques;
- the critical technologies to be developed and demonstrated;
- the development strategy and time schedule;
- the specific types of missions for which the technology is most suited.

These presentations were followed by a hands-on workshop in the afternoon, during which the students studied the application of low-thrust in-space propulsion. The students analyzed the performance of two low-thrust interplanetary mission profiles and compared the performance of these technologies with the performance of a mission based on conventional chemical propulsion techniques.

Core Curriculum lectures and workshops on propulsion during the month of July and a hands-on "Rocket Launch" activity on August 16 were integral supporting elements of the August 14 Theme Day. The Core Curriculum lectures (e.g., Introduction to Astrodynamics with an associated workshop on orbital mechanics, space propulsion with an associated workshop, and space transportation systems) involved ISU faculty and lecturers who came to Strasbourg specifically for this purpose. The "Rocket Launch" activity also involved ISU students, faculty and visiting lecturers.

A hand-out that was provided to the students explaining the elements of the Theme Day and indicating the international set of lecturers who participated in the Theme Day is attached.

Attachment

THEME DAY 'Upcoming Technologies' (14 August)

[original abstract written by Erik Slachmuylders]

The Theme 'Upcoming Technologies' will address two technologies, whose development is reaching such a level of maturity that their operational introduction may be expected within the next decade, and which will have a fundamental impact both on what missions can be envisaged and on how these missions will be performed. These are: micro & nanotechnology and in-space propulsion. In fact, at first sight these 2 technologies have opposite objectives: nanotechnology aims at the reduction of the mass of spacecraft, whereas the advanced in-space propulsion technologies aim at increasing the mass of the ultimate payload. These seemingly opposite objectives make these two complementary.

Micro & nanotechnology (also referred to by the acronym MEMS) allows the micro-miniaturization of spacecraft, thus paving the way for swarms of microsatellites performing either as a swarm or individually missions or functions not achievable hitherto. Microtechnology addresses the realization of traditional functions at a micro-scale by continuously decreasing the size of individual elements, whereas nanotechnology starts building up from the atomic level. Microtechnology has reached a fairly wider field of application, whereas nanotechnology is at present restricted to a few specific aspects.

In-space propulsion has become a major constraint on space exploration. For interplanetary missions, the capability of chemical propulsion systems limits the total mass that can be sent to the outer planets. In order to ameliorate this constraint, most such missions make use of a gravity assist maneuver, which unfortunately adds considerably to the duration of the mission. Electric or thermal in-space propulsion offer the advantage of large improvements in this area.

Electric propulsion, whether powered by solar generators or by nuclear reactors, offers a valuable solution to the problems posed by chemical in-space propulsion. It may be argued that solar electric propulsion is more applicable to near-Earth missions or to missions to the nearer planets, whereas nuclear electric propulsion remains operational even in the vicinity of the far outer planets. Taking into account considerations such as cost and safety it can be concluded that both types of electric propulsion are complementary having their specific niches of application. A third technology based on non-chemical sources for high efficiency propulsion is solar thermal propulsion, which may find its own specific niche in near-Earth missions or missions to the inner planets.

The Upcoming Technologies Theme Day will address the above new technologies addressing for each one:

- the principles of the technology and the resulting characteristics;
- the advantages and possibilities offered when compared with present-day techniques;
- the critical technologies to be developed and demonstrated;
- the development strategy and time schedule;
- the specific types of missions for which the technology is most suited.

These presentations will be followed by a hands-on workshop in the afternoon devoted to the in-space propulsion topic, during which the students will study the application of low-thrust in-space propulsion. The students will analyze the performance of two low-thrust interplanetary mission profiles and compare the performance of these technologies with the performance of a mission based on conventional chemical propulsion techniques.

Upcoming Technologies for Space – 14 August

last update: 12/8

Start	End	Activity	Lead
08:45	08:50	Introduction to Theme Day & MEMS	Philippe Berthe (EADS)
08:50	09:50	Micro/Nanotechnology & Interferometry	Eike Kircher (ESTEC)
09:50	10:00	Break	
10:00	10:05	Introduction to Space Propulsion	Philippe Berthe (EADS)
10:05	11:05	NASA Nuclear Power & Propulsion Program	Harley Thronson (NASA)
11:05	11:15	Break	
11:15	12:15	Low-Thrust Electric Propulsion	Giorgio Saccoccia (ESTEC)
12:30	13:30	Lunch	
13:45	14:45	Solar Thermal Propulsion	Dominique Valentian (SNECMA)
14:45	15:00	Break	
15:00	17:30	Propulsion Exercise	Nicolas Pillet, Franck Damon, Regis Bertrand (CNES)